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STRUCTURAL TIME-SERIES MODELS FOR FORECASTING YIELD OF PROMISING VARIETIES OF GRAM (Chickpea) CROP IN CHHATTISGARH

ROSHAN KUMAR BHARDWAJ[1], S. S. GAUTAM[2] & R. R. SAXENA[3]

[1]*Research Scholar, M.G.C.G.V, Chitrakoot, Satna M.P, India*

[2]*Associate Professor, M.G.C.G.V, Chitrakoot, Satna M.P India*

[3] *Professor, Igkv, Raipur C.G India*

ABSTRACT

Gram is an important pulse crop grown in the country with the average yield 8.13 q/ha as compared the Chhattisgarh state average yield 7.13 q/ha. For trend analysis of crops yield widely used by Auto-regressive Integrated Moving Average (ARIMA) time series methodology. An alternative approach, discusses yield trends of promising variety, which is quite potential, is the "Structural time series modelling. The study mainly confined to secondary collected for a period 2009-10 to 2014-15 data of promising varieties of Gram yield. As these techniques, it may be mentioned that models are fitted to the data and coefficient parameter value obtained on the basis of the model are compared with the actual observation for assessing the accuracy of the fitted model. To validate the forecasting ability of the fitted models, for the three years with upper and lower limit. The maximum Gram yield obtained Vaibhav variety with forecast for the year 2017-18 obtained 27.95 q/ha with upper and lower limit 41.16 and 14.75 q/ha. The minimum yield obtained JG-6 (7.82 q/ha) with upper and lower limit 1.37 and 14.28 q/ha respectively.

KEYWORDS: Structural Time Series Model, AIC, BIC, Goodness of Fit

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Original Article

INTRODUCTION

In Rabi season major crops are gram in 26 thousand hectare in area covered. Gram is an important pulse crop grown in the country with the average yield 8.13 q/ha as compared the Chhattisgarh state average yield 7.13 q/ha. Though the yield of Gram in the state is lower-than the national average but high yielding varieties in the state is higher than the state yield as well as national yield which is ranging between 7.00 to 27.00 q/ha. Promising variety is a popular variety and being cultivated widely. It may be a variety, an advance line, strain or land race (recommended or non-recommended). However, variety is a group of plants having distinct, uniform and stable traits which has been recommended for cultivation by a committee. There are many promising varieties of Gram, are available but it depends on cultivation practices and geographical areas where some specific varieties are more suitable for its better production in Chhattisgarh state.

For trend analysis of crops yield widely used by Auto-regressive Integrated Moving Average (ARIMA) time series methodology. This method can be applied only when either the series under consideration is stationary or it can be made so by differencing, de-trending, or by any other means. Another disadvantage is that this approach is empirical in nature and does not provide any insight into the underlying mechanism. An alternative approach, discusses yield trends of promising variety, which is quite potential, is the "Structural time series modelling (STM) (Harvey, 1996)".

Statistical modelling of crop yield data in Agriculture is usually carried out by employing ARIMA methodology (Brockwell and Davis, 1991). A quite promising, mechanistic approach, which does not suffer from this drawback, is "Structural time-series modelling (STM)". The techniques that emerge from this approach are extremely flexible and are capable of handling a much wider range of problems than is possible through ARIMA approach. Structural time series models are formulated in such a way that their components are stochastic; in other words, they are regarded as being driven by random disturbances.

The Akaike Information Criterion (AIC) is a measure of the relative quality of statistical models for a given set of data. Given a collection of models for the data, AIC estimates the quality of each model, relative to each of the other models. Hence, AIC provides a means for model selection. BIC is an estimate of a function of the posterior probability of a model being true, under a certain Bayesian setup, so that a lower BIC means that a model is considered to be more likely to be the true model. Once a model is estimated, its suitability can be assessed using goodness fit statistics.

MATERIALS AND METHODS

The study mainly confined to secondary collected for a period 2009-10 to 2014-15 data of promising varieties of Gram yield. Data collected from various publications, Government of Chhattisgarh were subjected structural time series model. The data are analyzed by using software Statistical Analysis System (SAS). Structural time series model adopted for forecasting purpose is given below.

Structural Time Series Model for Trend

A structural time series model is set up in term of its various components, like trend, cyclic fluctuations and seasonal variation, i.e.

$$Y_t = T_t + C_t + S_t + \varepsilon_t \quad (1)$$

Where Y_t is the observed time-series at time t, T_t, C_t, S_t, ε_t are the trend, cyclical, seasonal and irregular components.

- ***Local Level Model (LLM):*** In the absence of seasonal and cyclical components, eq. (i) reduces

$$Y_t = \mu_t + \varepsilon_t \quad \varepsilon_t \sim N(0, \sigma_\varepsilon^2) \quad (2)$$

Where

$$\mu_t = \mu_{t-1} + \beta_{t-1} + \eta_t$$

$$\beta_t = \beta_{t-1} + \xi_t \qquad t = \cdots, -1, 0, 1, \ldots,$$

Where $\eta_t \sim N(0, \sigma_\eta^2)$ and $\xi_t \sim N(0, \sigma_\xi^2)$ It may be mentioned that η_t, ξ_t, and ε_t are independent of one other. If $\sigma_\eta^2 = \sigma_\xi^2 = 0$, eqs.(vi) and (vii) collapse to

$$\mu_t = \mu_{t-1} + \beta \qquad t = 1, 2, \ldots, T \quad (3)$$

$$\mu_t = \alpha + \beta t \qquad t = 1, 2, \ldots, T, \quad (4)$$

- **Goodness of Fit**

Goodness of fit statistics is used for assessing overall model fit and models having equal number of hyper-parameter are assessed using Prediction Error Variances. If the number of hyper-parameters is different, one can use Akaike information criterion (AIC) which is given as

$$AIC = -2 \log L + 2n, \quad (5)$$

Where L is the likelihood function, which is expressed in terms of estimated one-step-ahead prediction errors. Here n is the number of hyper--parameters estimated from the model. Schwartz-Bayesian information criterion (SBC) is also used as a measure of goodness of fit which is given as

$$SBC = -2 \log L + n \log T, \quad (6)$$

Where T is the total number of observations. Lower the values of these statistics, better is the fitted model.

RESULTS AND DISCUSSIONS

The Yield Trends of Promising Varieties of Gram

In, recent years, structural time series model for functional estimation has become increasingly popular as a tool for time series data analysis. As these techniques, it may be mentioned that models are fitted to the data and coefficient parameter value obtained on the basis of the model are compared with the actual observation for assessing the accuracy of the fitted model. Structural trend model is applied to the data sets. Parameters estimated as well as goodness of fit statistics are presented in Table 1. Model is fitted to the data sets using Statistical Analysis System (SAS) statistical software package version 9.2.

Structural time series model are developed basically to trends find the forecast the yield. To validate the forecasting ability of the fitted models, for the three years with upper and lower limit. Evidently, initially there was an increase in all Gram promising variety yield in Chhattisgarh. Corresponding trend information of 11 (all varieties describes).

Table 1: Trend Information for Different Promising Gram Variety of Chhattisgarh

Promising Variety	Intercept	Slop	AIC	BIC
Vijay	11.67	-0.06	26.26	24.42
JG-6	10.17	0.78	27.28	25.44
JG-11	14.99	0.12	18.13	16.29
JG-14	10.81	-0.20	13.73	11.89
JG-16	13.19	0.32	27.84	26.00
JG-63	14.97	0.61	28.49	26.65
JG-74	16.38	0.39	24.74	22.90
JG-130	10.75	-0.48	29.04	27.20
JG-226	14.30	0.34	22.66	20.82
Vaibhav	15.98	3.98	22.05	20.21
JAKI-9218	13.20	0.42	21.96	20.12

It could be concluded from the Table 2 that the JG-14 variety have minimum AIC (13.73) and BIC (11.89) obtained among 11 high yielding varieties followed by JG-11 with AIC (18.13) and BIC (16.29) respectively. Thus the data clearly indicated that the maximum mean yield have Vaibhav variety. The maximum AIC (29.04) and BIC (27.20) obtained for the variety of JG-130.

Table 2: Forecast for Gram yield qt / ha

Variety	2015-16		2016-17		2017-18	
	Forecast	Standard Error	Forecast	Standard Error	Forecast	Standard Error
Vijay	11.61	2.72	11.55	4.16	11.48	5.45
JG-6	9.39	2.64	8.61	2.95	7.82	3.29
JG-11	15.11	1.09	15.24	2.18	15.36	3.53
JG-14	10.61	0.53	10.41	0.71	10.20	0.89
JG-16	13.52	2.83	13.84	3.16	14.17	3.53
JG-63	15.59	3.07	16.21	3.43	16.83	3.82
JG-74	16.78	1.92	17.17	2.14	17.57	2.39
JG-130	10.26	3.45	9.77	4.16	9.29	4.91
JG-226	14.64	1.48	14.99	1.65	15.33	1.84
Vaibhav	19.97	1.80	23.96	4.02	27.95	6.73
JAKI-9218	13.63	1.35	14.06	1.51	14.49	1.69
Vishal	17.36	2.34	19.00	3.38	20.64	4.70

The result in Table 2 and Table 3 found that maximum Gram yield forecast for the year 2017-18 about 27.95 q/ha with upper and lower limit 41.16 and 14.75 q/ha followed by yield of Vishal variety obtained 20.64 q/ha with upper and lower limit 29.86 and 11.41 q/ha respectively. The minimum yield obtained JG-6 (7.82 q/ha) with upper and lower limit 14.28 and 1.37 q/ha respectively. From the Table 2 it is observed that the forecasts using Structural time series model some varieties shows an increasing and some varieties shows decreasing trend for promising varieties of Gram in Chhattisgarh.

CONCLUSIONS

In our study the structural time-series model developed for Gram yield comparison of the state yield showed that the yield of high yielding / promising varieties are much higher (278 %) than the state yield of Gram. This indicates that the promotion of high yielding varieties can be made for improving the overall productivity of the state.

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APPENDICES

Table 3: Fitting of Structural Time Series

Variety	2015-16			2016-17			2017-18		
	Lower Limit	Upper Limit	Model Width	Lower Limit	Upper Limit	Model Width	Lower Limit	Upper Limit	Model Width
Vijay	6.26	16.96	10.70	3.38	19.72	16.34	0.78	22.18	21.40
JG-6	4.21	14.57	10.36	2.82	14.39	11.57	1.37	14.28	12.91
JG-11	12.97	17.25	4.28	10.95	19.52	8.57	8.43	22.28	13.85
JG-14	9.55	11.66	2.11	9.00	11.81	2.81	8.45	11.96	3.51
JG-16	7.96	19.08	11.12	7.64	20.05	12.41	7.25	21.10	13.85

Table 3: Contd.,									
JG-63	9.57	21.62	12.05	9.49	22.94	13.45	9.33	24.34	15.01
JG-74	13.00	20.55	7.55	12.96	21.38	8.42	12.87	22.27	9.40
JG-130	3.50	17.03	13.53	1.61	17.94	16.33	1.33	18.91	17.58
JG-226	11.74	17.55	5.81	11.74	18.23	6.49	11.71	18.95	7.24
Vaibhav	16.45	23.50	7.05	16.079	31.86	15.78	14.75	41.16	26.41
JAKI-9218	10.96	16.29	5.33	11.08	17.03	5.95	11.17	17.80	6.63
Vishal	12.76	21.95	9.19	12.37	25.62	13.25	11.41	29.86	18.45
Average width			**8.26**	**Average width**		**10.95**	**Average width**		**13.85**